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Report to Congressional Requesters

January 1991

OVER-THE-HORIZON RADAR

Better Justification Needed for DOD Systems' Expansion

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National Security and
International Affairs Division

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January 16, 1991

The Honorable J. James Exon
Chairman, Subcommittee on Strategic
Forces and Nuclear Deterrence
Committee on Armed Services
United States Senate

The Honorable Strom Thurmond
Ranking Minority Member
Subcommittee on Strategic Forces
and Nuclear Deterrence
Committee on Armed Services
United States Senate

As you requested, we (1) examined the Department of Defense's (DOD) plans to use the Air Force's Over-the-Horizon Backscatter (OTH-B) radar for counterdrug purposes and (2) are providing information on the cost, design, acquisition and deployment, missions, and interoperability of OTH-B and the Navy's Relocatable Over-the-Horizon Radar (ROTHR) programs.

Background

OTH-B was developed to support the North American Aerospace Defense Command's (NORAD) continental air defense mission. This mission consists of (1) tactical warning and attack assessment, the primary element for detecting, tracking, and assessing threat targets; (2) airspace control, the secondary element for controlling access to U.S. and Canadian airspace; and (3) damage limitation, the tertiary element, should an attack on North America ever occur.

OTH-B was specifically designed to provide early warning of an attack by detecting and tracking bomber-size (large and medium) aircraft. In the 1980s, DOD established a goal for OTH-B to detect and track cruise missiles (small targets), although a formal requirement was never established. This goal was recently suspended pending evaluation of a small target detection performance report and funding priorities.

DOD's plan for OTH-B includes four separate systems, each containing two or more integrated radar sectors, for a total of 12 sectors. The East Coast Radar System (eastern system) contains three operational sectors. The West Coast Radar System (western system) is still under construction and will also contain three sectors. The Alaskan Radar System is to

contain two sectors, and the Central Radar System is to contain four sectors. The Air Force has awarded separate contracts for the eastern and western systems and plans to award separate contracts for the Alaskan and central systems.

ROTHR was developed to support Navy fleet commanders' air defense mission. It was designed to provide air surveillance and warning of attacks by long-range aircraft (primarily bombers) on Navy battle groups and other U.S. and allied tactical forces. The ROTHR plan includes 12 separate systems, each containing a single radar sector. The systems are to be located in various geographical areas, including Virginia, Alaska, Guam, and the United Kingdom. The first operational system is in Alaska, and the Navy has three additional systems under contract, including an option to procure a fourth system.

In its planned fiscal year 1991 budget, the Air Force included $242.8 million for OTH-B—$214 million in other procurement and $28.8 million in military construction funds. Most of these funds were to procure and install the first central system sector for air defense purposes, positioning it toward the east.[1] Subsequently, the Deputy Secretary of Defense directed that the first sector be positioned toward the southwest (covering most of Mexico) for counterdrug purposes. The entire $242.8 million was then transferred from the Air Force's planned budget to DOD's fiscal year 1991 Drug Interdiction and Counterdrug Activities budget.

Results in Brief

Two actions led to conflicting information within DOD regarding the primary purpose of the central system—the shift in the first sector's radar coverage area from the east to the southwest and the transfer of planned funds for fiscal year 1991 from the Air Force's budget to the DOD counterdrug budget. Several DOD representatives stated that despite these actions, the primary purpose of the central system is still to support NORAD's air defense mission. We found that other factors were taken into consideration, specifically that (1) the goal for OTH-B, including the central system, to detect and track cruise missiles had been suspended and (2) the primary near-term benefit of the central system was judged to be in support of the counterdrug mission.

[1]Program officials informed us that $31.3 million of the $214 million in other procurement was planned for OTH-B systems other than the central system.

DOD's planned procurement of the first central system sector to support the counterdrug mission was not justified. This was primarily because the procurement decision was not based on a cost-effectiveness analysis of existing surveillance sensor alternatives. There are indications that ROTHR could be less costly than OTH-B. In terms of system performance for the counterdrug mission, the substantive differences between these two systems are less clear. A detailed cost-effectiveness analysis and adequate testing would be necessary to be conclusive. The analysis should include a mix of other existing radar systems and an assessment of the best geographical location(s) for an over-the-horizon radar to maximize system effectiveness. Neither OTH-B nor ROTHR was specifically designed to detect and track small general aviation aircraft used by drug smugglers. OTH-B operational testing, which was to include these type aircraft, will not be complete until 1991. ROTHR operational testing demonstrated a capability against these type aircraft, but the system has some performance limitations because it did not meet several effectiveness and suitability requirements.

The central system's contribution to NORAD's air defense mission is unclear because of changes that have occurred during the past several years regarding the system's planned use, the shifting priorities assigned to individual sectors, and the lack of satisfactory operational testing of the eastern system. For these reasons, an investment in the central system for air defense purposes would be premature. Any future decisions on budget requests for the central system should consider the following factors: (1) DOD's original plans for the central system as an air defense asset for detecting and tracking bombers; (2) DOD's emphasis on cruise missile detection capability during the 1980s, and the subsequent suspension of this effort; (3) the views of several DOD representatives that the central system is still primarily expected to support NORAD's air defense mission, despite the recent emphasis on counterdrug activities and the uncertainty of a bomber threat from the south; (4) the shifting priorities, and thus relative importance, of the various central system sectors; and (5) DOD's concurrence with our recommendation in 1989 that OTH-B performance be demonstrated through operational testing before making commitments to the central system.

Conflicting Information Regarding Central System's Primary Purpose

For several years, DOD planners expected the central system to be the fourth and final OTH-B system, providing contiguous radar coverage between the eastern and western systems for air defense purposes. Representatives from the Office of the Secretary of Defense, the Office of the Joint Chiefs of Staff, NORAD, and the Air Force stated that despite (1) the shift in the radar coverage area of the central system's first sector from the east to the southwest and (2) the associated transfer of planned fiscal year 1991 funds from the Air Force budget to the DOD counterdrug budget, the primary purpose of the central system is still to support NORAD's air defense mission. They view OTH-B's contribution to the counterdrug mission as an extension of the airspace control element of NORAD's air defense mission. However, using this as a justification for requesting fiscal year 1991 funds indicated that the first central system sector would be acquired for the secondary element of the air defense mission rather than the primary element—tactical warning and attack assessment. The DOD Deputy Assistant Secretary for Drug Enforcement Policy stated that the planned central system funds were included in the counterdrug budget for purposes of accountability and visibility over DOD's counterdrug efforts.

We found that DOD changed the planned funding for the first central system sector because (1) the goal for OTH-B, including the central system, to detect and track cruise missiles had been suspended and (2) the primary near-term benefit of the central system was judged to be in support of the counterdrug mission. We confirmed this with a DOD Deputy Comptroller involved in the funding transfer, and this led the Deputy Secretary of Defense to direct that the first central system sector be shifted from the east to the southwest for counterdrug purposes. Considering (1) DOD's emphasis on the southwest central system sector for counterdrug purposes and (2) the view of several DOD representatives that this sector's function would be an extension of the airspace control element of NORAD's air defense mission, we could find no evidence that this sector was considered critical for NORAD's primary air defense element of tactical warning and attack assessment—detecting and tracking bombers approaching the southern border of the United States.

Procurement of First Central System Sector for Counterdrug Purposes Not Justified

Procurement of the first central system sector for counterdrug purposes was not justified primarily because DOD's decision to request procurement and construction funds was not based on a cost-effectiveness analysis of existing surveillance sensor alternatives.

The United States is already employing several air surveillance assets to support the counterdrug mission. They include land- and sea-based aerostats, the Caribbean Basin Radar Network, fixed and mobile ground-based radars, the Airborne Warning and Control System aircraft, and Navy aircraft and ships with surveillance capability. At the time of our review, the Office of the Joint Chiefs of Staff was assessing radar coverage, radar systems, and data communications in support of DOD's counterdrug mission. Until such an assessment is completed, it is uncertain whether additional surveillance capability, like an over-the-horizon radar, is needed.

If an over-the-horizon radar system is needed as a counterdrug asset, the Navy's ROTHR could be an alternative radar that DOD should consider, along with a mix of other existing radar systems. The reason is that ROTHR could be less costly, and it may be able to satisfactorily perform the counterdrug mission. Other critical factors to consider are the best geographical location(s) for deploying such an over-the-horizon radar and the availability of satisfactory operational test data.

Estimated System Costs

Air Force and Navy data indicates that, on average, ROTHR could cost about $52 million less per sector to procure and install than OTH-B. Our approach to comparing the two systems' costs was based on averages, not a detailed analysis, because of differences in (1) how the two services allocated their costs for such things as site preparation, (2) construction costs at the various radar locations, (3) acquisition periods. We did not include estimates for operation and support costs that would extend over the systems' planned lives because such estimates usually require that special assumptions be developed. A detailed analysis of all costs would be necessary to be conclusive in determining which system is most cost effective.

Design Similarities and Differences

OTH-B and ROTHR have both design similarities and differences. Generally, the systems are functionally similar in what they do and how they do it—providing comparable wide-area radar coverage to detect and track aircraft by using the ionosphere to transmit high frequency signals beyond the horizon. Over-the-horizon radar experts at SRI International

stated that both radars were comparable in terms of providing the surveillance necessary for the counterdrug mission.

The systems are different in several other respects, including physical structure, electronics design, power output, and target correlation capability. For example, OTH-B software is designed to correlate aircraft tracks with flight plan data for the purpose of reporting uncorrelated targets. ROTHR does not have a similar correlation capability, but can filter certain aircraft out by course and speed. In addition, OTH-B has more transmitting power than ROTHR that may make it more capable at certain times. However, ROTHR has more receive beams than OTH-B that may make it more capable under certain environmental conditions. A technical analysis would be required to determine how significant these and other differences are in relation to the counterdrug mission.

Deployment Locations

The central system, which is to be located in the north central states, and the ROTHR system to be located in Virginia are candidate systems to support the counterdrug mission. However, the planned locations of these systems were not specifically chosen for counterdrug purposes. The central system sites were chosen to provide radar coverage of areas that were advantageous for detecting and tracking sea-launched cruise missiles. The central system would not provide coverage into Central and South America where drug traffic originates.

Although the single ROTHR sector planned for Virginia would provide radar coverage of the Caribbean area, a second ROTHR system located at the same site in Virginia, but looking in a southwesterly direction over the Gulf of Mexico and most of Mexico, may not be optimally located for the counterdrug mission. This is because of a special target tracking situation (referred to as radial velocity) relative to the position of the radar that could prevent or limit detection of aircraft traveling in a northwest direction from Columbia to Mexico.

In March 1990, SRI International representatives briefed DOD officials on an experimental over-the-horizon radar, located in California, called the Wide Aperture Research Facility. They stated that this radar could provide coverage to the southeast along the U.S. and Mexico border and beyond for drug interdiction operations, but that it could only be used part-time. A study for the Office of the Joint Chiefs of Staff pointed out that this radar included 20-year-old technology and was not designed to provide continuous 24-hour-a-day surveillance. It also questioned the radar's reliability and supportability.

The location(s) of any over-the-horizon radar to be used for counterdrug purposes is critical. This is because the system would need to be positioned to cover the most likely air traffic patterns of drug smugglers.

Operational Testing

Neither OTH-B nor ROTHR was specifically designed to detect and track small general aviation aircraft used by drug smugglers. However, Air Force and Navy officials expressed confidence that their respective systems would perform well against these type targets.

The Air Force view regarding OTH-B is based on computer simulations; development testing, including special small target tests; and limited operation of the eastern system. The Air Force plans to include small aircraft in its initial operational test and evaluation of the eastern system. However, this test and evaluation is incomplete and the results may not be available until mid-1991.

The Navy view is based on development and operational testing of the ROTHR prototype. However, overall results from the latest operational evaluation (OT-IIB) showed that ROTHR had some performance limitations because it did not meet several effectiveness and suitability requirements. The DOD Director of Operational Test and Evaluation's assessment of these test results was that ROTHR was not ready for a full-rate production decision. The Navy is planning another operational evaluation (OT-IIIA) and believes that the effectiveness and suitability problems can be corrected prior to it.

Central System Contribution to the Air Defense Mission Is Unclear and an Investment Would Be Premature

Since the early 1970s, DOD expected the central system to be the fourth and final OTH-B system, providing contiguous radar coverage between the eastern and western systems with a military mission of detecting and tracking bombers and large air-to-surface missiles. At that time, DOD planned on a two-sector central system to look southeast and southwest of the United States. The system was to be located in the Texas and Oklahoma area to provide the greatest reasonable range of radar coverage.

In 1982, after the cruise missile (small target) threat was identified, DOD changed its planned location for the two-sector central system to the north central states. This location was chosen to provide better coverage of likely launch areas for sea-launched cruise missiles. In 1983, DOD identified a need for two additional central system sectors to look east and west, providing coverage in areas referred to as "skip zones" that were

not covered by the eastern and western systems. Again, the primary concern was with sea-launched cruise missiles. In fiscal year 1988, the OTH-B program office received $47.1 million to initiate a product improvement program to enhance OTH-B software and hardware for detecting air- and sea-launched cruise missiles. Despite these three significant actions in response to the cruise missile threat (changing locations, planning for two additional sectors, and initiating product improvements), Air Force officials stated that cruise missile detection was never a requirement for OTH-B, only a goal.

Also in 1988, DOD deleted two of the four planned central system sectors from the program because of budget constraints. The southwest and west sectors were deleted, indicating that the southeast and east sectors had higher priority for air defense purposes. Of these two priority sectors, the Air Force planned to install the east sector first. It therefore requested funding in its planned fiscal year 1991 budget which was submitted to the Office of the Secretary of Defense in mid-1989.

After using one eastern system sector to test OTH-B against small targets in 1988, DOD suspended its efforts in 1989 to enhance OTH-B's capabilities to detect and track cruise missiles pending evaluation of the small target detection performance report and funding priorities. As of our review, these efforts had not been continued, indicating that the central system's primary contribution to the air defense mission would more likely be associated with detecting and tracking larger targets such as bombers. However, there is some uncertainty regarding the threat of such targets from the south. The Air Force stated that while the threat from the south is not great in terms of expectations of attack by Latin American countries, Soviet long-range aviation forces possess the capability to mount an attack from any direction. The Air Force position is that OTH-B is needed to meet requirements based on capabilities, not perceived intentions of potential or real adversaries. The Air Force also stated that Cuba possesses the means to execute military air operations in the Gulf of Mexico and the Caribbean.

In late 1989, based on plans to restructure the OTH-B program because of budgetary constraints, NORAD changed the priority for the two central system sectors. It stated that the first central system sector should be oriented toward the southeast because it would provide surveillance of the current "hot" area for drug traffic and would provide contiguous coverage of the east and southeast coastlines. It then stated that the second central system sector should be oriented toward the southwest because it would provide the only deep look capability into Mexico, a

major staging area for drug traffickers. This indicated that NORAD placed more emphasis on the counterdrug mission than the air defense mission. It also indicated that a two-sector central system would not include the east and west sectors; thus the central system plan is now essentially the same as it was in the early 1970s, except for the radar site's physical location in the north central states. NORAD, nevertheless, still states that a four-sector central system is needed for the air defense mission.

Finally, the Air Force's plan to perform an initial operational test and evaluation of the integrated three-sector eastern system has resulted in continuous delays. In early 1989, we recommended that the Secretary of Defense ensure that OTH-B system performance, in terms of detecting and tracking large and small targets, be adequately demonstrated through operational testing before making commitments to the central system. This recommendation was based on our conclusion that test delays and threat changes could pose unwarranted program risks until certain performance questions were addressed. DOD concurred with this recommendation. At that time, the test had been delayed 22 months from its originally planned date of December 1987. The test, which began in June 1990, was actually delayed 30 months. However, in July 1990, the test was suspended pending further evaluation and is now scheduled to be restarted in the January to March 1991 time period. Until this operational test is satisfactorily completed, an investment in the central system would be premature and could continue to pose unwarranted program risks. In his February 1990 annual report, the DOD Director of Operational Test and Evaluation stated that what was originally a build-test-fix-retest-production program for OTH-B has become a concurrent design-production program because of design integration problems.

Congressional Action on the Fiscal Year 1991 OTH-B Funding Request

Based on our briefing to you in June 1990, and subsequent budget analysis,[2] the Congress had the benefit of most of the information contained in this report during its fiscal year 1991 deliberations on the DOD budget. In the National Defense Authorization Act for Fiscal Year 1991, the Congress required DOD to study the need for an over-the-horizon radar located in the central part of the United States and directed toward Mexico and to submit the results to the congressional defense committees. Instead of authorizing the full $242.8 million for OTH-B, the Congress authorized $25 million and stipulated that the funds may not be obligated until 30 days after (1) the Secretary of Defense certifies

[2]Air Force Budget: Potential Reductions in Command, Control, and Communications Funds (GAO/NSIAD-90-300BR, Sept. 28, 1990), pp. 31-33.

that such a system is needed, meets the requirements of the drug interdiction program, and would be the most cost-effective system and (2) the DOD Office of Test and Evaluation certifies that the eastern OTH-B system meets all contract requirements and performance specifications, in the event that OTH-B is determined to be the most suitable over-the-horizon radar system for counterdrug purposes.

In regard to DOD's fiscal year 1991 appropriations, the Congress provided $25 million in procurement funds to the Air Force for OTH-B and deleted the $242.8 million requested in DOD's Drug Interdiction and Counterdrug Activities budget. In addition, the House Committee on Appropriations directed the Air Force to perform a dual mission study to assess OTH-B performance in the counternarcotics and small target tactical warning and attack assessment areas.

Matters for Congressional Consideration

The Congress should consider requiring DOD to clarify the primary purpose of the central radar system. If the primary purpose is for the air defense mission, rather than the counterdrug mission, future budget requests for the central system should be justified on that basis, describing what threat the system is expected to detect. In addition, the Congress should consider requiring DOD to demonstrate that satisfactory operational test results have been achieved on the east coast radar system before providing funds for any additional OTH-B sectors.

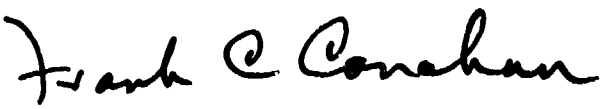
As agreed with your offices, we did not obtain official agency comments. However, we discussed the contents of this report with DOD officials and have incorporated their comments where appropriate.

We are sending copies of this report to the Secretary of Defense; the Director, Office of Management and Budget; selected congressional committees; and other interested parties. Copies will be made available to others upon request.

Appendix I provides detailed information on OTH-B and ROTHR. Appendix II contains our objectives, scope, and methodology.

This report was prepared under the direction of Louis J. Rodrigues, Director, Command, Control, Communications, and Intelligence Issues. If

you have any questions about this report, he can be reached at (202) 275-4841. Other major contributors are listed in appendix III.



Frank C. Conahan
Assistant Comptroller General

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Abbreviations

ARS	Alaskan Radar System
CRS	Central Radar System
DOD	Department of Defense
ECRS	East Coast Radar System
NORAD	North American Aerospace Defense Command
OTH-B	Over-the-Horizon Backscatter
ROTHR	Relocatable Over-the-Horizon Radar
WARF	Wide Aperture Research Facility
WCRS	West Coast Radar System

DOD's Over-The-Horizon Radar Programs

The Department of Defense (DOD) has two over-the-horizon radar programs—the Air Force's Over-the-Horizon Backscatter (OTH-B) radar and the Navy's Relocatable Over-the-Horizon Radar (ROTHR). Each radar system consists of transmitters and receivers that are located approximately 100 nautical miles apart and an operations control center. The transmitters send high frequency signals into the ionosphere that are then refracted downward and reflected off aircraft and other objects. The reflected signals return via the ionosphere to the radar receivers and are processed by computers for target display at the operations control center.

The OTH-B program consists of four separate systems, each containing two or more integrated sectors. Each sector provides area coverage between 500 and 1,800 nautical miles from the radar site, over a 60-degree azimuth. The East Coast Radar System (ECRS), which is located in Maine, contains three sectors that provide 180 degrees of coverage primarily over the Atlantic Ocean and extend from Greenland to the West Indies. The West Coast Radar System (WCRS) also contains three sectors that provide 180 degrees of coverage primarily over the Pacific Ocean and extend from Alaska almost to Mexico. The transmitters, receivers, and operations center are located in Oregon, California, and Idaho, respectively. The Alaskan Radar System (ARS) is planned to contain two sectors that would provide 120 degrees of coverage over a portion of the North Pacific Ocean, the Aleutian Islands, and a portion of the Soviet Union. The Central Radar System (CRS) is planned to contain four sectors that would provide 240 degrees of coverage. CRS's two inner sectors would extend south beyond the United States and include the Gulf of Mexico, portions of the Caribbean Sea, most of Mexico, and a portion of the eastern Pacific Ocean. Its two outer sectors would provide coverage of ocean areas called "skip zones" near the east and west coasts of the United States that are not covered by ECRS and WCRS. The transmitters, receivers, and operations center are to be located in South Dakota, Minnesota, and North Dakota, respectively. Altogether, the four OTH-B systems contain 12 sectors. However, one of the ARS sectors and the two outer CRS sectors are not currently included in the Air Force's program baseline because of budget constraints. The North American Aerospace Defense Command (NORAD), nevertheless, stated that 12 OTH-B sectors were still needed for the air defense mission.

The ROTHR program consists of 12 separate systems. Each system provides radar coverage primarily over ocean areas between 500 and 1,600 nautical miles from the radar site, over a 64-degree azimuth. The systems are planned to be located in various geographical regions

throughout the world including Virginia, Alaska, Guam, and the United Kingdom.

Estimated Costs

There are indications that ROTHR could cost less that OTH-B. This was shown to be the case in a counternarcotics sensor mix study, performed by the Joint Electronic Warfare Center at the direction of the Office of the Joint Chiefs of Staff. Also, the cost information we obtained from Air Force and Navy program offices showed that, on average, ROTHR could cost about $52 million less per sector to procure and install than OTH-B. Our approach to comparing the two systems' costs was based on averages, not a detailed analysis, because of differences in (1) how the two services allocated their costs, for such things as site preparation, (2) construction costs at the various radar locations, and (3) acquisition periods. We did not include estimates for operating and support costs that would extend over the systems' planned lives because such estimates usually require special assumptions. A detailed analysis of all costs would be necessary to be conclusive in determining which system is most cost effective.

OTH-B Costs

The Air Force estimated that total OTH-B program acquisition costs would be almost $2.6 billion, as shown in table I.1. This is to develop, procure, and install four separate systems consisting of 12 sectors over a 16-year period from the development decision in 1982 to program completion in 1997. The first sector was acquired with research and development funds. The average procurement and military construction costs per sector for the remaining 11 sectors are $187.7 million.

Table I.1: OTH-B Estimated Program Costs

Dollars in millions

Air Force appropriation accounts	Total	Average cost per sector
Research, development, test, and evaluation	$514.1	
Other Procurement	1,955.0	$177.7
Military construction	109.5	10.0
Total	**$2,578.6**	**$187.7**

[a]Not applicable

Because the first CRS sector is being considered by DOD to support the counterdrug mission, we requested the OTH-B program office to provide a

separate cost estimate for the planned two-sector CRS. The office estimated the procurement and construction costs to be $320.1 million, or an average of $160.1 million per sector.

ROTHR Costs

The Navy estimated that total ROTHR program acquisition costs would be almost $1.8 billion, as shown in table I.2. This is to develop, procure, and install 12 separate systems over a 16-year period from the development decision in 1983 to program completion in 1998. The first sector was acquired with research and development funds. The average procurement and military construction costs per sector for the remaining 11 sectors are $135.7 million.

Table I.2: ROTHR Estimated Program Costs

Dollars in millions

Navy appropriation accounts	Total	Average cost per sector
Research, development, test, and evaluation	$291.4	
Other Procurement	1,113.6	$101.2
Military construction	379.5	34.5
Total	**$1,784.5**	**$135.7**

[a]Not applicable.

Based on the current Navy contract that was awarded in December 1989 to procure the first three ROTHR systems, the negotiated costs for a single ROTHR sector range from about $75 million to about $80 million, including initial spare parts, tools, test equipment, and installation at a prepared site, but excluding administrative and program support. ROTHR military construction costs, which include preparing the site, have ranged widely, according to the program manager, from about $10 million for the Virginia site to about $100 million for the Alaska site. The Navy expects a typical ROTHR sector would require about $20 million in military construction. In total, Navy documents show that the cost for a complete, typical ROTHR system would be about $108 million—$79 million in procurement, $20 million in military construction, and $9 million in administrative and program support.

Cost Summary

We used two different approaches to compare OTH-B and ROTHR costs. The results were the same in both cases, showing that on average, ROTHR could cost about $52 million less per sector than OTH-B. First, using the Air Force's and Navy's estimated procurement and construction costs for 11 OTH-B sectors and 11 ROTHR sectors, respectively, the average OTH-B

cost per sector is $187.7 million, and the average ROTHR cost per sector is $135.7 million—a difference of $52 million. Second, the estimated average cost per sector for a future CRS is $160.1 million, while the estimated average cost for a typical ROTHR sector, based in part on the current contract, is $108 million—a difference of $52.1 million.

Selected Design Similarities and Differences

OTH-B and ROTHR have both design similarities and differences. How well the systems will perform relative to the operational requirements could be different and needs to be determined through operational testing. Generally, the systems are functionally similar in what they do and how they do it. Table I.3 shows some of the design similarities, and table I.4 shows some of the design differences.

Table I.3: Selected Design Similarities

Radar type	Both systems are ground-based, have separate transmitter and receiver sites, and use the ionosphere to refract signals to and from targets beyond the horizon.
Operating frequency range	Both systems operate from 5 to 28 megahertz, which is in the high frequency range.
Sector coverage	Both systems have approximately the same two-dimensional area of coverage per sector. OTH-B coverage extends from 500-1,800 nautical miles from the antennas with a 60-degree azimuth. ROTHR coverage extends from 500-1,600 nautical miles from the antennas with a 64-degree azimuth.
System purpose	Both systems are to detect and track bomber-size aircraft

Table I.4: Selected Design Differences

	OTH-B	ROTHR
Physical structure	Stationary	Relocatable
Electronics design	Vacuum tubes	Solid state
Power output	1,200 kilowatts	200 kilowatts
Signal strength at low frequencies	About 5 decibels more gain than ROTHR	About 5 decibels less gain than OTH-B
Transmit antennas	Uses 6 frequency bands	Uses 2 frequency bands
Approximate receive antenna length	5,000 feet	8,000 feet
Receive beams for target location	3 beams, 2.5 degrees wide	16 beams, 0.5 degrees wide
Target correlation	Compares radar tracks with aircraft flight plans on file	No similar correlation capability, but can filter by course and speed
Operations	Single operations center for multiple radar sectors	Single operations center for each radar sector
Primary message channels	Data reported to Air Force and NORAD command centers using Air Force message structure	Data reported to Navy command centers using Navy message structure

Acquisition and Deployment Status and Schedules

The Air Force's four planned OTH-B systems are in various stages of the acquisition and deployment process—one is operational but has yet to complete operational testing, one is still under construction, and contracts have yet to be awarded for the other two. Similarly, the Navy's 12 planned ROTHR systems are in various stages—one is operational and is scheduled to undergo additional operational testing, three are under contract, and the remainder have yet to be acquired.

Air Force OTH-B

In 1982, the Air Force awarded a contract to develop the initial ECRS operating sector. In fiscal years 1984 and 1985, the Congress appropriated procurement funds for sectors 2 and 3, respectively. ECRS is now installed and is being used in a limited operational mode and for initial operational test and evaluation purposes.

In fiscal years 1986, 1987, and 1988, the Congress appropriated funds for WCRS sectors 4, 5, and 6, respectively. WCRS is still under construction, but the Air Force reported that two of the three sectors began operating in June 1989.

The Congress appropriated fiscal year 1989 funds for the first ARS sector. The Air Force then requested fiscal year 1990 funds for the

second ARS sector, but it underestimated ARS costs, resulting in these funds also being used for the first sector. In November 1989, NORAD lowered its priority for the second ARS sector. Instead of installing this sector immediately after the first sector, as originally planned, NORAD now prefers that the second sector be installed after three of the four CRS sectors (southwest, southeast, and east) are installed, assuming funds are available. The Air Force's plans to award the ARS contract have been delayed pending resolution of operational testing difficulties on ECRS.

DOD's fiscal year 1991 request for OTH-B funds was to initiate procurement of the first CRS sector (southwest) to be deployed in the north central states. However, the Congress denied most of the request.

Navy ROTHR

In 1983, the Navy began full-scale development of the ROTHR prototype. The prototype was deployed to southeastern Virginia for development and operational testing. The Navy's operational test agency reported that based on its operational evaluation (OT-IIB) during April and May 1989, ROTHR met some, but not all, of its effectiveness and suitability requirements. Overall, the agency concluded that ROTHR has the potential to be operationally effective in conducting air surveillance, but not ship surveillance, and has the potential to be operationally suitable. Based on this evaluation, the Navy awarded the first ROTHR production contract in December 1989 to procure three systems, including an option for a fourth system, to be deployed in Virginia, Guam, the United Kingdom, and Alaska.

In late fiscal year 1989, the Navy moved the prototype system from Virginia to Amchitka, Alaska, for operational use and follow-on testing. In February 1990, the DOD Director of Operational Test and Evaluation reported that ROTHR did not meet the effectiveness and suitability requirements necessary for a full-rate production decision. However, the Navy has scheduled an operational evaluation (OT-IIIA) for late 1990, which is intended to support a full-rate production decision. It believes that the operational effectiveness and suitability problems can be corrected prior to this evaluation. Assuming OT-IIIA is successful and a full production decision is favorable, the Navy plans to exercise the contract option for the fourth system in April 1991 and procure the remaining seven systems, one each year, from fiscal years 1992 through 1998.

Planned and Alternative Deployment Locations

The Air Force's planned CRS and the Navy's ROTHR system located in Virginia have been discussed within DOD as candidate systems to support DOD's counterdrug mission. Also, SRI International officials suggested to DOD that its experimental radar system be used. However, the locations of these three systems were not specifically chosen for counterdrug purposes.

OTH-B in the North Central United States

In the early 1970s, the Air Force planned to install two CRS sectors in the south central United States—Texas and Oklahoma. These sectors were to look southeast and southwest to detect bomber-size aircraft. This location would have provided the greatest reasonable range of radar coverage of southern approaches to the United States.

In the early 1980s, the atmospheric threat expanded to include air- and sea-launched cruise missiles. To better meet the sea-launched cruise missile threat, the Air Force changed the planned CRS location from the south central states to the north central states—North Dakota, South Dakota, and Minnesota. The southeast- and southwest-looking sectors would provide radar coverage beyond the southern U.S. border, including the Gulf of Mexico, portions of the Caribbean Sea, most of Mexico, and a portion of the eastern Pacific Ocean. However, they would not provide coverage into Central and South America where considerable drug traffic originates.

NORAD representatives stated that a recent analysis showed the north central states to still be the preferred location for CRS. They stated that moving CRS further south would (1) sacrifice contiguous coverage at the outer extremes of CRS and "open penetrating seams" between the ECRS, WCRS, and CRS coverage areas and (2) disrupt the schedule by having to initiate the environmental impact process again.

ROTHR in Virginia

The first production ROTHR system is to be located at the test and evaluation site in southeastern Virginia where the prototype was originally installed. Its primary purpose is to provide radar coverage of the Caribbean Sea and part of Central America to the northern edge of South America. In addition, it will be used for operator training, software development, and other product improvements. This Navy location would provide much deeper radar coverage southeast of the United States than the Air Force's southeastern CRS sector.

The ROTHR contractor stated that adding a second system alongside the planned system at the existing southeastern Virginia site would expand ROTHR coverage to all of the Gulf of Mexico, the remainder of Central America, and all but the northwest portion of Mexico. However, the contractor did not consider this to be the optimal location for the counterdrug mission. This is because of a special target tracking situation (referred to as radial velocity) relative to the position of the radar that could prevent or limit detection of aircraft traveling in a northwest direction from Columbia to Mexico. Instead, the contractor stated that a ROTHR located in the southwestern United States could provide better radar coverage of Mexico and the Gulf of Mexico.

The Navy said an environmental assessment, not a full environmental impact study, would be needed for a second ROTHR at the Virginia site. However, if new locations are chosen, an environmental impact study would be necessary.

SRI International System in California

In March 1990, SRI International representatives suggested to DOD officials that the SRI over-the-horizon radar system in California, called the Wide Aperture Research Facility (WARF), could provide a surveillance capability for the counterdrug mission on an interim basis pending deployment of CRS. WARF is an experimental system that has been used for research and development since 1966.

The officials stated that WARF could initially be put into use about 10 percent of the time looking southeast along the U.S. and Mexico border and beyond. With equipment and software upgrades costing about $7.5 million, they stated WARF could be available in fiscal year 1993 for border surveillance up to about 45 percent of the time. They also stated that because WARF is an existing, active facility, there are no significant environmental impact issues involved.

Factors Relative to Mission Changes

Both OTH-B and ROTHR were primarily designed to detect bomber-size aircraft. For several years, DOD planned for both systems to have additional missions—OTH-B was to detect and track smaller targets, specifically cruise missiles, and ROTHR was to detect and track ships. However, based on testing, these additional missions were suspended.

OTH-B Missions

DOD officials anticipated that OTH-B would have some capability to detect and track air- and sea-launched cruise missiles (small targets)—a more

difficult task than detecting larger targets. They established a goal to enhance OTH-B capabilities and received funds to initiate a product improvement program for this purpose. However, based on small target testing in early 1988, Air Force officials suspended this goal in 1989 pending evaluation of the small target detection performance report and funding priorities.

Regarding the counterdrug mission, OTH-B was not specifically designed to detect and track small general aviation aircraft, nor has there been a formal requirement to support such a mission. However, NORAD and Air Force officials stated that based on computer simulations and limited operations of ECRS, they have confidence that OTH-B could detect these type aircraft. To provide greater assurance, NORAD and Tactical Air Command representatives directed that testing against small aircraft be included in the ECRS initial operational test and evaluation. An Air Force Operational Test and Evaluation Center representative stated that the testing would include using (1) small commercial aircraft identified through flight plans and (2) small aircraft flown by aero clubs, including any known military flights. The operational test, however, is not likely to be completed until mid-1991.

ROTHR Missions

Based on OT-IIB, ROTHR was judged not operationally effective for ship surveillance. As a result, further evaluation of ROTHR's ship surveillance capability was deferred until the follow-on operational test and evaluation (OT-IIIA) scheduled to start in late 1990.

Regarding the counterdrug mission, ROTHR was not specifically designed to detect and track small general aviation aircraft, nor is there a formal requirement to support such a mission. However, during development and operational testing, ROTHR demonstrated a capability to detect and track these smaller aircraft.

Extent of Interoperability

NORAD is planning to integrate ROTHR data into its command and control systems from three ROTHR locations—Alaska, Virginia, and the United Kingdom. Because these ROTHR systems would be covering areas beyond OTH-B coverage, the major contribution would be to provide early cueing of possible targets headed into OTH-B coverage areas.

In 1987, the Air Force and Navy established a working group to develop communications protocol and data requirements for integrating ROTHR

data into NORAD's command and control system. For example, the capability now exists for the Navy to provide, via the defense data network, target tracks from ROTHR to NORAD command and control centers. However, the Air Force is planning to automate this function under an Air Force project called Atmospheric Tactical Warning Connectivity. This project, which is estimated to cost $75 million over a 5-year period, is intended to modify certain Air Force capabilities to integrate, display, and forward data to NORAD from OTH-B, ROTHR, and other sensors under advanced development. It would not modify ROTHR to provide a target correlation capability. Overall, an Air Force official stated they do not see any technical challenge to integrating ROTHR data, the major impediment being funding.

NORAD representatives expressed doubt that substituting ROTHR for CRS could be easily done. They stated that for ROTHR to be useful to NORAD operations, it must, for example, be capable of (1) correlating targets by using International Civil Aviation Organization flight plan data, (2) integrating operations of two or more sectors, and (3) converting ROTHR data to be usable by NORAD systems. Currently, ROTHR is not designed to do these functions. Contractor and Navy cost estimates to write software for ROTHR to allow target correlation ranged widely from about $5 million to about $20 million, indicating that a more detailed estimate may be necessary. The Navy is currently considering the integration of two ROTHR sectors, and the program manager said that the savings in hardware costs would offset the software integration costs. Contractor representatives informed us that software to convert ROTHR data to a usable Air Force format would cost from $5 million to $10 million, while a Navy representative estimated the cost at about $50,000, again indicating the need for a more detailed estimate.

Objectives, Scope, and Methodology

The Chairman and Ranking Minority Member, Subcommittee on Strategic Forces and Nuclear Deterrence, Senate Committee on Armed Services, requested that we (1) examine Department of Defense (DOD) plans to use the Air Force's Over-the-Horizon Backscatter (OTH-B) radar for counterdrug purposes and (2) obtain information on the cost, design, acquisition and deployment, missions, and interoperability of OTH-B and the Navy's Relocatable Over-the-Horizon Radar (ROTHR) programs.

We interviewed DOD officials responsible for the two radar programs within the Office of the Secretary of Defense, Office of the Joint Chiefs of Staff, Department of the Air Force, and Department of the Navy in Washington, D.C. We also interviewed government officials at the Air Force Electronic Systems Division, Hanscom Air Force Base, Massachusetts; Space and Naval Warfare Systems Command, Crystal City, Virginia; NORAD, Colorado Springs, Colorado; and selected contractor representatives. We reviewed and analyzed planning and contractual documents, cost and schedule information, system requirements and design data, and correspondence.

We performed our work from March to August 1990 in accordance with generally accepted government auditing standards.

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